

NEW APPROACHES TO AGGREGATION OF INDICATORS AT PERFORMANCE EVALUATION USING THE BALANCED SCORECARD METHODOLOGY

SABOL Ján¹

¹BPM Consulting, s.r.o., jsabol@bpmc.sk

¹The Slovak Association of Business Process Management, jan.sabol@sapria.sk
Kosice, Slovakia, EU

Abstract

Leading organizations agree on the need for a structured methodology for using performance measurement information to help set agreed-upon performance goals, allocate and prioritize resources, confirm or change current policy or program directions to meet those goals, and report on the success in meeting those goals. The evaluation of enterprise performance forms an inevitable precondition for maximum business success achievement. Any enterprise should be able to know their performance from the perspective of several interconnected and balanced indicators at any instant of time. Moreover, the successful application of performance measuring process makes it possible to identify the economy and efficiency of programs, processes and applied enterprise resources.

Currently, there are methods and integrated tools designed to manage companies in a proactive way using strategic planning. Furthermore, they also help to monitor and evaluate enterprise influence using a balanced set of indicators and understand the aim of business activities. Even though current evaluation methods of enterprise performance offer sets of balanced performance evaluating indicators, in reality, the achieved results and outputs are **not completely accurate** and, many times, misleading. That is the reason why it is appropriate to focus on principles of performance multi-criteria evaluation that would be based on relevant mathematical and statistical methods using **new approaches to aggregation of indicators** at performance evaluation.

Keywords: Balanced Scorecard, Business Process Management, Multi-criteria evaluation, Performance Evaluation, Vector Calculus

1. INTRODUCTION

Nowadays it is common to say that “what cannot be measured, cannot be managed”. That is why successful application of a performance measuring process, thanks to which market leading enterprises can find out the economy and efficiency of programs, processes and applied resources, is one of the features of market leaders. The above-mentioned process of performance measurements does not end with the data gathering and analysis. Its main output is the improvement and successful implementation of the defined strategy. This can be solved by integrated tools, thanks to which it will be possible to manage enterprises in a proactive manner using planning, monitor business activities using “score-carding” and understand such activities using Business Intelligence. That is why there are so many auxiliary tools developed, the goal of which is to make it possible and easier for the enterprises to survive in a competitive environment in the long term.

Strategic management, i.e. the highest level of enterprise management activities, closely relates to enterprise performance. The issue of strategic management and performance evaluation has been in the centre of enterprises' as well as consulting and IT companies' attention for a long time. The consulting and IT companies are trying to develop a solution for the given issue using well-established methods and software tools. In many enterprises both in the Slovakia and abroad, it is still more common to have traditional performance evaluation systems mainly focusing on financial statements and dealing with past performance. However, this is no longer sufficient. Financial indicators usually evaluate what was performed in an enterprise and do not focus on its

future efficiency. Furthermore, they do not evaluate enterprises comprehensively, i.e. non-financial indicators included.

A number of enterprises are not satisfied with the existing state of reporting and management documents. It is necessary to develop a tool for the improvement of their long-term strategic planning and management. Survey results show that traditional activity measuring systems that are based on external data were insufficient. Moreover, the existing solutions, based on the Balanced Scorecard methodology, do not provide reliable aggregated information necessary for management control and decision making. Today's enterprises need an effective planning and management tool that provides information with the highest information value capability.

2. METHODS OF BUSINESS PROCESS MANAGEMENT AND PERFORMANCE EVALUATION

The evaluation of enterprise performance is based on principles, procedures, conceptions and methods of business process management. Performance evaluation closely relates to enterprise strategic goals of all management levels.

2.1. The best known Business Process Management methods

Process orientation, as it was described, is nowadays becoming an inevitable precondition for the enterprise to be able to make its mark in the environment of continuous changes. It is well-known that expected changes usually occur faster and more effectively if a process-based approach to enterprise management is applied and all the activities are managed as processes. There are quite a lot of methods that are based on process approach. The scope of this work, however, makes it impossible to deal with them all in detail. There are below described those of them that are the most important from enterprise process management point of view.

- a) **Project management** - its principles relate to the development of the network analysis and graph theory. It is a process of human, material and financial resources management and coordination during the project supposing modern management methods are used. This process focuses on the achievement of predefined goals in the extent, cost, time, and quality and project participant satisfaction given. Defined goals must be achieved under the condition of respected strategy defined and under the application of specific procedures, tools and methods related to the planning and management of individual project processes.
- b) **Activity Based Costing (ABC)** - this covers costs calculated on the basis of activities. This method was developed in the 80's of the 20th century. When implementing the ABC method it is necessary to know in detail all company processes and their mutual relations, on the basis of which we classify this method as a concept based on process approach. The basic principle of this method says that it is the product and not the activity that invokes costs. Based on that, the method focuses on costs as process attribute. Identification of the process and activities.
- c) **Balanced Scorecard (BSC)** - the concept of evaluation indicator balanced system that talks about the balance of individual enterprise areas in the view of such enterprise strategy. The areas in question: financial, process and customer area and learning and growth dimension area. It is a tool used to enforce strategic changes that should serve the top management to start with and should be gradually developed downwards for all business units. This is a long-distance race. Fast and large-area deployment of BSC does not usually lead to success. It is not generally known that if BCS is to be successfully deployed a functioning process and information infrastructure in the operational and tactical company management must exist. Otherwise it would resemble "sales of vacuum cleaners in areas without any power line established". The BSC method is one of the most renowned approaches to the interconnection of company visions, strategic goals and operational planning and decision-making.

Basic points of view (perspectives): [3][4][5][6]

- Financial perspective - it mainly focuses on the monitoring and evaluation of financial indicators such as cash flow, profit etc.;

- Customer-related perspective - it also focuses on indicators, but different ones, namely indicators important for the customer such as the price and quality of the product, services related to the product and of course customer satisfaction.
 - Process perspective - from this perspective, critical processes, i.e. those with direct effect on customer satisfaction are the subject to monitoring. These processes are measured and their level of effectiveness is defined.
 - Learning and growth perspective (education and innovation, i.e. potential); it tries to specify company characteristics required for its continuous progress, fulfilment of the goals defined and company ability to adapt to both, external and internal changes.
- d) **Re-engineering based on process approach** - it is a revolutionary approach of enterprise process improvement; re-engineering is a rather comprehensive concept based on process approach. A distinct feature of this method is the focus on process changes supposing that these changes have to be carried out in a radical manner. According to the authors of this concept, namely M. Hammer and J. Champy, re-engineering represents radical reevaluation and reorganisation of company processes so as to achieve dramatic improvement related to critical performance indicators such as costs, quality, time period and promptness of reacting on customer requirements. [8][9][14]
- e) **KAIZEN** - a Japanese philosophy representing continuous improvement of company processes; it is the best-known and the most comprehensive method that enabled Japanese companies to achieve indisputable success. It is mainly based on Japanese life philosophy, according to which each subsequent day must be a little bit better than the current one. This approach tries to achieve gradual rather than rapid improvement by taking care of the smallest details that can be modified or improved. This concept is based on the absolute familiarity with processes. Without this familiarity no result improvement can be expected. That is the reason why it is classified as a process approach concept. Unlike the methods based on revolutionary changes, such as re-engineering, the goal of KAIZEN method is to achieve process gradual improvement, which is the feature also common for the following methods:
- KVP (Kontinuierlicher Verbesserungsprozess) - improvement applied in VW and Opel automotive factories,
 - Continuous Improvement - continuous improvement developed in the USA,
 - Ideen Management - a method of improvement applied in Audi automotive factories,
 - ZEBRA (Zlepšenie Ekonomickej Budúcnosti Realizovaním Aktuálnych Nápadov/ Economic Future Improved through Current Ideas Implementation) - this method is applied in Škoda Auto automotive factories. [8][9][14]
- f) **Other techniques - e.g. process benchmarking** - this is a process of systematic comparison of processes, products and services as well as given enterprise performance indicators with other successful enterprises. Information the enterprise acquires this way must be turned into knowledge, the goal of which is to achieve business growth, provide for company development and ensure a strategic advantage.

2.2. The Balanced Scorecard methodology - short description

Balanced Scorecard is a strategic performance measurement system supporting strategic planning and management by synchronising the entire company activities through consistent objective understanding and through facilitating evaluation of the current company situation in relation to its strategic objectives accomplishment and achievement. This system has become the core management information system of most companies using Balanced Scorecard.

2.2.1. Why companies need Balanced Scorecard ?

Mr. Robert S. Kaplan and Mr. David P. Norton, professors of Harvard University, USA, introduced Balanced Scorecard methodology in report published in 1992 in the Harvard Business Review as a response to great

number of U.S. companies requirements that expressed dissatisfaction with current reporting and documentation conditions related to management. They were focused on financial statements and dealt mostly with past performance.

The authors of Balanced Scorecard methodology sought to create a tool for improvement of long-term strategic planning and management. Results indicated that conventional measurements based on external data are insufficient. Information society organisations needed something more, an effective planning and management tool. For that purpose Kaplan and Norton introduced four various viewing angles enabling evaluation of company operation. They consist in **financial scope, customer satisfaction, enterprise internal processes, education and innovation** within the enterprise.

The financial scope represents more or less a conventional enterprise performance measurement system. The other three scopes, the so-called perspectives, based on management or intangible assets evaluate the company success in the course of long-term operation.

The formation process of the enterprise “balanced score” (Balanced Scorecard) implies to shape visions of respective strategic objectives and operation plans to reach these objectives. It includes therein the entire organisation i.e. the contribution of each individual to insure enterprise performance in future and to achieve the so-called balanced score between financial indicators and non-financial scopes. The Balanced Scorecard acts through testing in real time. The user can incorporate feedback from commercial and other company operations in favour of score modification and improvement.

2.2.2. Balanced Scorecard methodology elements

Balanced Scorecard methodology has more elements which are used during the performance evaluation model development. The global Balanced Scorecard framework is illustrated on the following **Figure 1**.



Figure 1 The global Balanced Scorecard framework

3. BALANCED SCORECARD - NEW APPROACHES TO AGGREGATION OF INDICATORS

Current Balanced Scorecard aggregation approaches and methods have several disadvantages. The problem is an aggregation, respectively the summary of elements (indicators) from lower levels to higher in case of different units of measurement for some subordinate elements. Such cases are a routine when evaluating the enterprise performance.

3.1. Disadvantages of current approaches and methods

At present software tools use for aggregation of indicators with different measure of units so-called **RANGE**

function. By using the range limits, we can visualize and compare the values of elements. The range limits provide boundaries to the areas between range limits, which are called ranges. The value assigned to the range is helpful when comparing the elements. Since the elements may use different measure units, these range values help to provide a common unit by which the elements can be compared and aggregated. For example, if we have three ranges: Poor, Average, and Excellent, then they could be assigned the range values of 0, 5, and 10. These range values can be used in formulas to create a common unit for calculating the values of elements that use different measure units. From the above example we can see that the range values carry a relatively large uncertainty, which is compounded in the greater number of performance evaluation levels (measurements, group measurements, key performance indicators, etc.). One solution is to increase the number of range limits and areas between them, but we never achieve in this way accurate and relevant results from aggregated values. It is therefore appropriate to deal with the idea of finding new ways and means of data aggregation in enterprise performance evaluation by Balanced Scorecard methodology.

3.2. Vector calculus and the most convenient algebraic operation

Vector calculus is a branch of mathematics concerned with differentiation and integration of vector fields, primarily in three dimensional Euclidean space R^3 . The term "vector calculus" is sometimes used as a synonym for the broader subject of multivariable calculus, which includes vector calculus as well as partial differentiation and multiple integration. The basic objects in vector calculus are scalar fields (scalar-valued functions) and vector fields (vector-valued functions). These are then combined or transformed under various operations, and integrated. The analysis of vector calculus operations (sum of vectors, product of a vector and scalar, vector length, scalar product of vectors, vector product of vectors, mixed vector product) shows that the **vector length** is the most convenient operation for aggregation of performance indicators. The mentioned operation is defined in any n -dimensional space and the result is a scalar, thus the value of performance evaluation indicator, which **fully meets the needs** of aggregation of performance evaluation indicators. The vector length, which is also otherwise referred to as a so-called "**quadratic average**" also due to the fact that the length of the vector is proportional to the length of vector coordinates. The basic principle in performance evaluation process is to use the **same method (operation)** for all aggregations which occur in the performance evaluation model. It is all about the aggregation of indicators with different measurement units. Of course, the same method can be used also at the lowest levels of performance evaluation model, if relevant, but at these levels are generally used approved proportional economic and other indicators of performance evaluation of processes and organization as a whole.

4. PROCEDURE OF PERFORMANCE EVALUATION IN THE USE OF VECTOR CALCULUS

The issue of data aggregation with different measurement units is the subject of several research projects and publications. Approaches to solving this problem are varied, but the objective is the same, to achieve such performance indicator values which correspond to reality, and to their explanatory power.

4.1. The current state of software tools to implement the Balanced Scorecard methodology

Current software tools using the Balanced Scorecard methodology use the so-called **RANGE** function for aggregation of performance indicators with different measurement units. The function has the following features - see **Figure 2**.

By using the range limits, we can visualize and compare the values of indicators. The range limits can provide boundaries to the areas between range limits, which are called ranges. The value assigned to the range is helpful when comparing the indicators. Since the elements may use different measurement units, these range values help to provide a common unit by which the elements can be compared. For example (see **Figure 2 - Maximize** case), if we have three ranges: **Poor**, **Average**, and **Excellent**, then they could be assigned the range values of **0**, **5**, and **10**. These range values can be used in formulas to create a common unit for

calculating the values of indicators that use different measurement units. The same is the case when we aim to **minimize** the values of performance indicators, with the only difference that the various ranges are rotated 180°, thus in the order bottom-up: Excellent, Average, Poor. If we want to **stabilize** the indicator values we define the lower and upper alarm and also lower and upper target. The application of RANGE function is similar to that in the above cases.

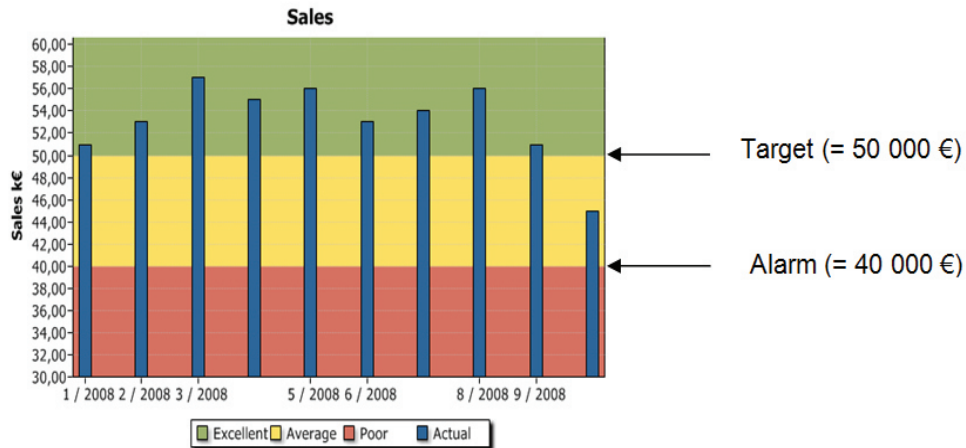


Figure 2 Ranges in the indicator of “Sales”

From the above examples it is seen that there come up to rather **large inaccuracy** in scoring at aggregation of performance indicators depending on the sensitivity (number of ranges) of defining individual ranges. Number of ranges is infinite, but this leads to a very complex, complicated and in practice unusable solution. Usually there are defined only alarm and target values and from them are derived individual ranges of performance evaluation indicators.

4.2. The proposed method of aggregation of indicators in the Balanced Scorecard methodology

The analysis referred to in the section 3.2 has showed that the calculation of the **vector length** is the most appropriate operation on the aggregation of performance evaluation indicators. Due to the fact that the measurement units of the indicators are at higher levels of a performance evaluation model usually different and of different range of values the first phase is to normalize individual indicators and transform them into a predefined range, the so-called **cardinal extent**.

The procedure of standardization:

Let: TAR = Target, ALA = Alarm, LALA = Low Alarm, LTAR = Low Target, UTAR = Upper Target and UALA = Upper Alarm, ACT = Actual Value, ATAR = Average Target, NTAR = Normalized Target, NALA = Normalized Alarm, NLALA = Normalized Low Alarm, NLTAR = Normalized Low Target, NUTAR = Normalized Upper Target, NUALA = Normalized Upper Alarm, NACT = Normalized Actual Value.

In practice, the majority of cases are the type of “**maximization**” (*the bigger, the better*) in the performance evaluation process. Other possible cases, “**minimization**” (*the lower, the better*) and “**stabilization**” (*the more stabilized, the better*), we can transform to maximize cases to avoid inconsistencies in a given multi criteria performance evaluation. Most indicators of performance evaluation shall take non-negative values or they can be transformed into indicators with these values. For example, the indicator "Profit or loss before tax" we can replace by the indicator "Cost - revenues ratio", which shall be only of positive value.

Individual cases will be therefore normalized as follows:

a) MAXIMIZE case:

In this case is valid: $0 \leq ALA < TAR$.

Then:

$$NTAR = \frac{TAR}{TAR}, \quad NALA = \frac{ALA}{TAR}, \quad NACT = \frac{ACT}{TAR}.$$

b) MINIMIZE case:

In this case is valid: $0 \leq TAR < ALA$.

Then:

$$TAR = \frac{TAR}{TAR}, \quad \text{where } TAR \neq 0. \text{ If } TAR = 0, \text{ then } NTAR = 1.$$

$$NALA = \frac{TAR}{ALA},$$

$$NACT = \frac{TAR}{ACT},$$

where $ACT \neq 0$. If $ACT = 0$, then we substitute the ACT for any very low value (for example 0,001) that has a negligible effect on the operation result.

c) STABILIZE case:

In the case of stabilization is valid: $0 \leq LALA < LTAR < UTAR < UALA$.

Let's define:

$$ATAR = \frac{LTAR + UTAR}{2}$$

The values of indicators we obtain from the following relationships:

$$NTAR = \frac{ATAR}{UTAR},$$

$$NALA = \frac{LALA}{ATAR}.$$

If $ACT < ATAR$, then

$$NACT = \frac{ACT}{ATAR}.$$

If $ACT \geq ATAR$, then

$$NACT = \frac{ATAR}{ACT}.$$

In a similar manner we proceed in the case if there are more levels of the planned values, not just two (ALA , TAR), or four in the STABILIZE case ($LTAR$, $UTAR$, $LALA$, $UALA$).

If an indicator can have also negative values, due to the elimination of inconsistency, we will use the above RANGE function (scoring method), where the result of the operation is divided by 10, so we got to the range with that we are considering in standardization.

Calculation of indicators:

The calculation of indicators, where relevant (various measurement units in subordinate items - coordinates of the vector), is performed according to the following formula:

Let the indicator (vector) $\mathbf{a} = (a_1, a_2, \dots, a_n)$ in normalized form, weights of coordinate squares are w_1, w_2, \dots, w_n , then the vector length of \mathbf{a} is as follows:

$$|\mathbf{a}| = \sqrt{w_1 a_1^2 + w_2 a_2^2 + \dots + w_n a_n^2} .$$

Recommendation:

$$\sum_{i=1}^n w_i = 1.$$

We use the same formula for each type of value, i.e. NTAR, NALA, NACT and others, if defined.

A geometric interpretation of using the vector length in performance evaluation process is shown on the **Figure 3**.

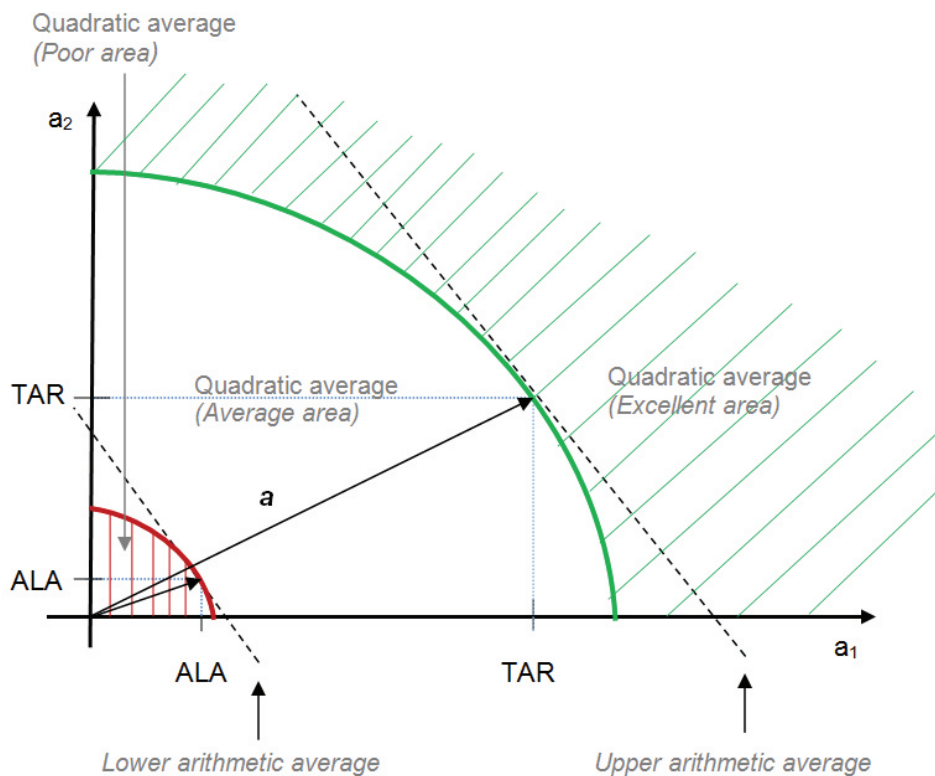


Figure 3 A geometric interpretation of using the vector length in performance evaluation process

5. CONCLUSION

In order to evaluate performance based on predefined indicators, enterprises usually apply standard software, e.g. spreadsheet programs such as MS Excel, Open Office Calc, MS Visio etc.

They, however, need more effective support software tools which would:

- make the process of the Balanced Scorecard model generation and result more transparent and simpler,
- determine mutual relations,
- define appropriate action plans,
- deal with selected parts of the model,
- generate flow diagrams,
- provide appropriate graphical environment and use available means of communication (internet, network connection etc.) in order to be able to use Balanced Scorecard and to automate any system of management strategy generation.

Once the company decides to invest in the Balanced Scorecard solution, it is necessary to select an appropriate methodology and software tool. This selection should be mainly based on the functionality the BSC application software offers in individual phases of the implementation project. It should also stay focused

on the functionality in the time of its active application. The relevant software offers various advantages. It makes it possible to access strategic maps of other management functional areas (it also prevents unauthorised persons from accessing). Moreover, the software makes it possible to see whether the initiatives led to any change in indicator values, „comments“ on achieved goals and automatically generates warnings for the competent ones about any adverse trends of performance indicators.

The current aim of many companies is to implement new concepts and methodology of process performance measurement so as to provide the most credible data for the evaluation of the company as a whole in relation to its strategic objectives.

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